Issued April 23, 1912.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY.—CIRCULAR 184.

A. D. MELVIN, CHIEF OF BUREAU.

THE PASTEURIZATION OF MILK

BY

S. HENRY AYERS,
Bacteriologist, Dairy Division.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., November 3, 1911.

Sir: I have the honor to transmit herewith, and to recommend for publication as a circular of this bureau, the accompanying manuscript, entitled "The Pasteurization of Milk," by S. Henry Ayers, bacteriologist in the Dairy Division of this bureau.

Efficient pasteurization is a safe means of guarding against infection, and when the temperature of pasteurization is not excessive this process probably causes no injury to the quality or appearance of the milk. Pasteurization also enhances the keeping properties, though the ordinary grades of milk when properly pasteurized under commercial conditions will still sour. It is especially valuable as a means of rendering reasonably safe the ordinary market milk, much of which would otherwise be dangerous to health; yet pasteurization is not to be regarded as a substitute for cleanliness, and its use as an attempt to hide the defects of dirty or otherwise unfit milk should not be countenanced.

Pasteurization in the final container which is received by the consumer is the ideal method, as in this way there is no danger of the milk becoming infected between the time of pasteurization and the time of its receipt by the consumer. This method has not yet been found practicable for general commercial use, however, chiefly on account of its expense and the lack of suitable machinery; but efforts are being made to adapt it to such use.

When one considers the enormous quantity of milk which is necessary to supply a large city, and the large number of producers from whom the milk must come, it is realized that the opportunities for contamination are very great. On this account raw milk for a city milk supply should be the exception rather than the rule, and such milk should be permitted to be sold only when there is the very closest supervision with regard to the health of the cows and attendants and the cleanliness of premises, equipment, and methods of handling the milk.

Milk dealers, dairymen, and farmers generally should profit from the full information which is given in this paper regarding the various methods of pasteurization. The paper also includes descriptions and illustrations of a number of the best types of machines adapted for the work both on the farm and in plants where large quantities of milk are handled.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

THE PASTEURIZATION OF MILK.

MEANING OF THE TERM "PASTEURIZATION."

Pasteurization as applied to milk is the process of heating for a short or long period as the different methods demand at temperatures usually between 140° and 185° F. The process must be followed by rapid cooling. The term originated from the experiments of Pasteur, in France, from 1860 to 1864, on the "diseases" of wine, in which he found that heating for a few moments at a temperature of 122° to 140° F. was sufficient to prevent abnormal fermentations and souring in the wine. A little later Pasteur found that by a similar heating beer could be preserved from souring. The application of the process gave rise to the term "pasteurization."

VALUE OF PASTEURIZATION.

The value of pasteurization from a sanitary standpoint is of the greatest importance when market milk is under consideration.

In the first place, the pasteurization of milk, when the process is properly performed, affords protection from pathogenic organisms. Such disease-producing bacteria as *Bacillus tuberculosis*, *B. typhi*, *B. diphtheriæ*, and the dysentery bacillus are destroyed, or at least have lost their ability to produce disease, when heated at 140° F. for 20 minutes or more. Although the infective agent in scarlet fever is unknown, epidemics of the disease have been traced to milk supplies, and in such cases pasteurization has been resorted to as a means of safeguarding the public, with apparently satisfactory results.

In the second place, pasteurization causes a reduction of the infantile death rate due to the ordinary intestinal disturbances. Numerous experiments definitely prove the value of pasteurization in this connection. While it has not been possible to isolate any special organisms which act as the causative agents in the common infantile intestinal troubles other than the one producing dysentery, it seems that high bacterial numbers in the milk consumed are associated with such diseases.

In the third place, pasteurization is of value from a commercial standpoint in so far as it increases the keeping quality of the milk and prevents financial losses caused by souring. Commercial pasteurization as practiced at the present time with reasonable care destroys

about 99 per cent of the bacteria, but it does not prevent the ultimate souring of milk, although it does delay the process.

Many objections have been raised to pasteurization. These are discussed fully in Bulletin 126 of the Bureau of Animal Industry of this department.

QUALITY OF THE MILK TO BE PASTEURIZED.

Only clean milk should be pasteurized, and it should never be pasteurized more than once. Dirty milk containing many millions of bacteria per cubic centimeter is not fit for consumption, and should be condemned. Pasteurization should not be resorted to in order to make dirty milk sweet long enough to be sold or simply to pass legal regulations, but should be used only to make clean milk a safe milk.

Milk to be considered clean should be produced in barns free from manure and floating dust. The cows should be curried every day, and their flanks and udders wiped with a damp cloth just before milking. The milkers should wear clean suits, and their hands should be clean and dry. All milking utensils should be cleaned and partly sterilized by steam or boiling water. After milking the milk should be removed at once to a milk house to be cooled, and it should be kept cool during delivery. A farm producing milk under the above conditions would score at least 70 points according to the score card of the Dairy Division.

METHODS OF PASTEURIZATION.

Milk is pasteurized by two processes, one known as the "flash" or "continuous" process, in which the flowing milk is heated to the required temperature and held there from 30 seconds to 1 minute. The other is known as the "holder" or "holding" process, and sometimes the term "held pasteurization" is applied. By the latter method the milk is held for approximately 30 minutes at the temperature desired.

The general arrangement of the machinery used in pasteurization is shown in figure 1. The sketch shows the use of one milk pump, which makes almost a gravity system. It is seen that the pasteurizer and holding tank are placed on a higher level than the cooler and bottling machine, so that after the milk is pumped to the supply tank it will flow by gravity through the whole system.

Before heating, milk is often filtered through absorbent cotton, sand, or quartz filters. The cotton will remove only coarse particles of dirt, while the sand and quartz filters, if properly operated, will remove some of the sediment from the milk. The desirability of the use of filters is not to be discussed in this paper, but when such filters are used they should be placed in the system between the receiving tank and the pasteurizer. In some plants the milk is clarified by

being separated and then mixed again before pasteurizing, this being done to remove particles of dirt, the greater part of which will remain in the separator. When the milk is to be separated it should flow from the receiving tank to a milk heater, where it is heated to 100° F., then to the separator which empties into the supply tank for the pasteurizer. The use of a separator does not decrease the bacteria; in fact, it apparently increases the bacterial content of the milk. The increase is not an actual one, however, but is due to a breaking up of the clumps of bacteria so that when a bacterial determination is made, instead of a clump of bacteria developing as one colony on a plate, the clump has been broken up into a number of individual organisms, each of which appears later as a separate colony. When each colony is counted and is assumed to represent one organism in the milk, obviously the bacteria are apparently increased by the process of separation of the milk.

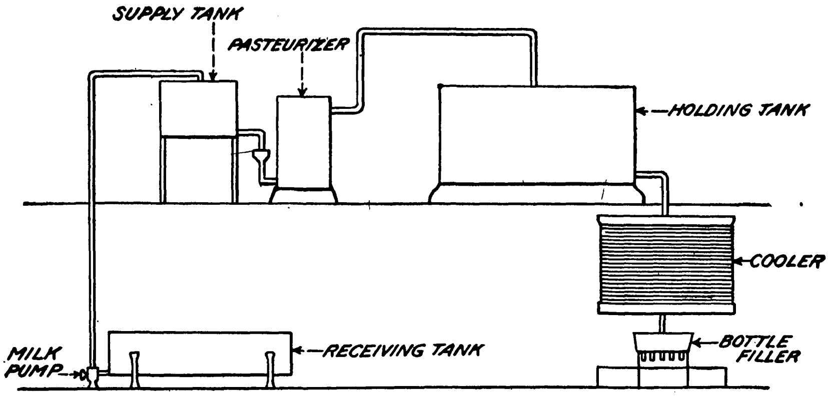

FIG. 1.—General arrangement of machinery for pasteurizing milk.

THE "FLASH" PROCESS.

The method of pasteurizing by the flash process is as follows:

The milk flows from the receiving tank to the pasteurizer, where it is heated at temperatures from 160° to 165° F. for from 30 seconds to 1 minute. After heating it flows to the cooler, where it is cooled to from 35° to 45° F., and is then immediately bottled and placed in refrigerators at temperatures ranging from 35° to 45° until time for distribution.

THE "HOLDER" PROCESS.

The holder process is the same as the flash process, except in the temperatures used and the length of the heating period. The milk is heated in the same pasteurizer as in the flash process, but at lower temperatures—140° to 150° F. After being heated it flows to the

holding tank, as shown in figure 1, where it is held for approximately 30 minutes, and is then cooled and bottled as in the flash process.

ADVANTAGES OF THE HOLDER PROCESS.

The holder process possesses numerous advantages over the flash process. To insure a complete destruction of disease-producing organisms with the holder process a temperature of 140° F. for 30 minutes is sufficient. With the flash process a temperature of 160° F. or higher is required to accomplish the same result. A much higher percentage reduction of bacteria can be obtained with the holder process than is possible with the flash process unless very high temperatures are used, and the bacterial reductions will be more uniform in the holder process, due to the heating of all the milk to the required temperature. When using a flash machine it is often found that the percentage bacterial reduction is greatly lowered, even though the temperature is carefully maintained. Such an occurrence is due to the fact that all of the milk is not heated to the temperature indicated by the thermometer. Again, the use of the high temperatures necessary for efficient results by the flash process is objectionable on account of the cooked taste produced in the milk, and because of the reduction of the cream line and the possibility of some chemical alteration of the milk. With the lower temperatures of the holder process no cooked taste is produced, there is no noticeable reduction of the cream line, and only slight chemical changes, if any at all, take place. Finally, the use of lower temperatures is preferable, from a financial standpoint, as they effect a saving in the cost of steam for heating and in refrigeration for cooling.

PASTEURIZATION IN BOTTLES.

Milk is at present pasteurized in bottles on a small scale, especially at the infant milk depots. In these cases small feeding bottles are filled with milk, then corked and placed in a chamber where the milk is raised to the pasteurizing temperature either by steam or by hot water. The milk is then cooled gradually by placing the bottles in water at lowered temperatures until they can be placed in ice water.

This method of pasteurization in bottles has not been used as yet in this country on a large scale. Recently Dr. Charles E. North[1] has suggested that the process is entirely practical on a commercial scale. He points out that milk may be pasteurized in corked bottles in the same type of machine in which bottled beer is pasteurized. Milk pasteurized by this method would be free from any possibility of reinfection from the time of pasteurization until it reached the consumer. If this method can be practiced with speed and economy

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[1] Medical Record, vol. 80, no. 3, p. 111.

it will undoubtedly prove superior to all others. Numerous processes have been patented, and one machine is being manufactured to pasteurize milk in the sealed bottle. Doubtless the method will gain in popularity as its merits are recognized, but pasteurization in sealed bottles makes necessary an entirely new equipment in a milk plant. It is doubtful if a company which has $20,000 to $30,000 worth of modern pasteurizing machinery in its plant will feel justified or even inclined to make a change which means the discarding of its expensive equipment only to have to replace it with expensive machinery of another type.

BOTTLING PASTEURIZED MILK WHILE HOT.

In order to avoid entirely new equipment for pasteurizing and at the same time accomplish practically the same results as in bottle pasteurization the bottling of milk while hot is suggested. This process is in an experimental state and will be the subject of further study in the research laboratories of the Dairy Division.

The process may be outlined as follows: The milk after being pasteurized by the holder process at 145° or at 150° F. is bottled and capped without cooling and allowed to stand until the temperature has dropped to 130° F., which requires about 15 minutes, varying with the temperature of the air. The bottles are then cooled by placing in ice water. With this method of bottling the milk while hot the process of pasteurization is completed in the bottle, thus destroying pathogenic organisms which might have infected the bottle; in other words, practically pasteurizing the bottle after capping. In our experiments we have found that bottles may be filled with hot milk at 150° F. and even higher, then placed at once in ice water without breaking. When milk at a temperature of 150° F. is placed in a bottle and capped the temperature drops to 140° F. in about 10 minutes at ordinary room temperature. There is therefore 10 minutes' pasteurization in the bottle at a temperature above that usually considered effective for pasteurization. The length of the heating in the bottle may be increased by holding the bottle of hot milk in a warm room. The bottles of hot milk may be handled on mechanical conveyers which carry them for the holding period and then be cooled by having the conveyer run through tanks of ice water. Ordinary caps may be used, but in that case care must be taken to see that the ice water does not reach the top of the bottle. With the use of crimped metal-capped cork seals the bottles are rendered water tight and can then be submerged in ice water for cooling. When milk is bottled hot there is a slight shrinkage on cooling, which, however, is of no great importance.

The only equipment necessary to adapt this method to the holder process of pasteurization is a conveyer and a cooling tank. The

mechanical details of the process depend only on the output of the milk plant and may be widely varied. It is believed that this method of bottling milk while hot will make it possible to achieve practically the same results as bottle pasteurization without necessitating the purchase of an entirely new equipment.

SELECTION OF MACHINERY.

THE PASTEURIZERS.

There are numerous pasteurizers on the market, for which the respective manufacturers claim various merits. In selecting a machine one should consider the various types carefully. Two points in particular should be kept in mind, namely, the simplicity of the machine and the ease with which it may be cleaned. A pasteurizer with inaccessible parts or one which requires considerable time to take apart for cleaning should never be used. The machine should be constructed so as to use hot water for the heating agent instead of direct live steam. Milk is usually heated by being forced against or circulated over hot surfaces, and when steam is used the milk may leave the machine at the desired temperature, say 160° F., but certain portions may be forced against a very hot part of the heating surface and be heated above that temperature. Such milk will be neutralized by milk not heated so high, so that the whole may give the required temperature of 160° F. Such heating, however, produces a scorched milk and will reduce the cream line to a considerable extent. On the other hand, when hot water is used for heating, the heating surface can be kept at a constant temperature. The water in the pasteurizer is heated by steam introduced into the water jacket or circulating water system, depending on the type of machine.

When purchasing a pasteurizer, one of larger capacity than is required by the milk supply should be selected. If a machine of small capacity is used for a large supply the milk must be forced through more rapidly than is normal for the machine. This makes the use of hotter heating surfaces necessary to give the pasteurizing temperature and results in the overheating of the milk, thereby producing a scorched product with a reduced cream line.

There are numerous pasteurizers on the market, the construction and method of operation of which are in a very general way discussed in the following pages. The drawings are not intended to show the exact construction of the machines, but are merely to show the principles of operation.

The construction of one of the simple types of pasteurizer is shown in figure 2. This machine consists of a milk chamber with revolving paddle, which is surrounded by a steam and water jacket. When the steam is turned on preliminary to heating the milk it enters the

jacket through three sets of jets, which may be seen joining the steam pipe. The steam condenses and the jacket is soon filled with water so that the milk is heated by hot water, the temperature of which is maintained by the jets of steam. The milk flows into the pasteurizer through the milk inlet at the bottom and is thrown by the centrifugal action of the revolving paddle against the sides of the hot-water jacket, and is then forced out at the top through the

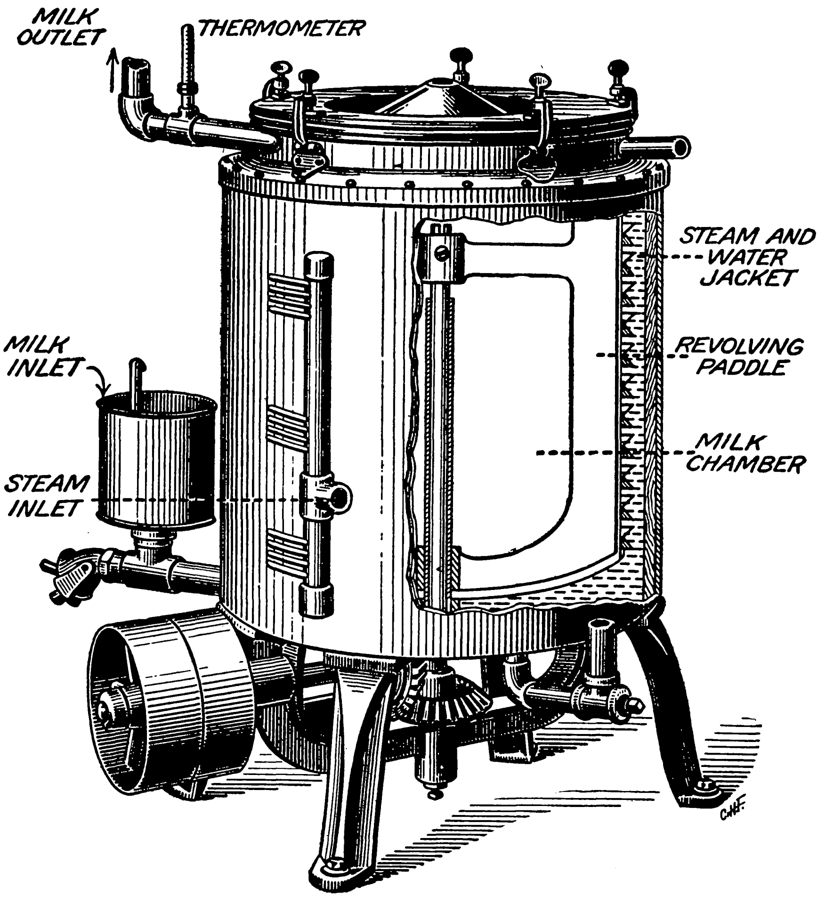

Fig. 2.—A simple type of pasteurizer.

milk outlet pipe. The temperature of the milk is shown by a thermometer as it leaves the machine. Pasteurizers of this type will force the milk to a height of 4 feet above the machine, which makes them convenient to use when it is necessary to elevate the milk to a holding tank or cooler.

Another type of simple pasteurizer is shown in figure 3. The machine consists of a water-jacketed cylinder, inside of which revolves

a drum. The water is heated by a steam discharge into the water pipe connecting with the water jacket. When in operation the milk enters through the milk inlet and is drawn by the centrifugal action of the revolving drum over it between its surface and the hot-water jacket, and is forced out through the milk outlet. A machine of this type will also elevate milk several feet.

Figure 4 shows a conical type of simple pasteurizer. This machine consists of a conical heating drum, over which revolves a skeleton frame carrying a tape which constantly wipes the heating surface. Steam is introduced at the bottom of the drum through standing

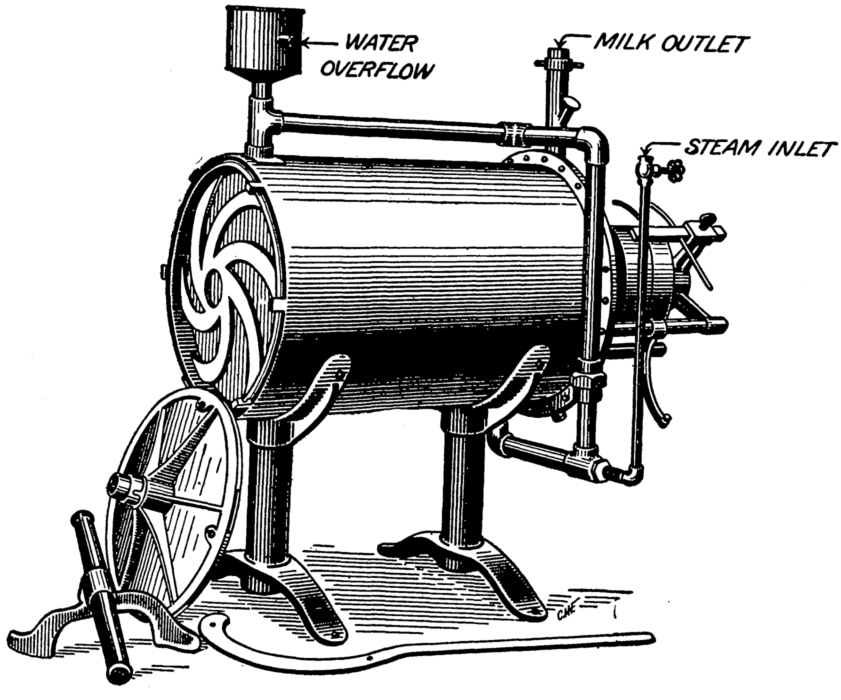

FIG. 3.—Another simple pasteurizer, showing cover removed.

water and is forced through it up against the heating drum. During the operation of the machine the milk enters at the top and passes through holes in the bottom of the reservoir down over the heating drum. The revolving tape keeps the milk from burning on the drum and keeps the surface of the latter clean. When the milk reaches the bottom of the heating drum it is caught in a trough and is then pumped to the holding tank or cooler.

In figure 5 is shown a type of simple pasteurizer through which milk flows by gravity. The milk enters at the top and flows down through the milk space, as shown in the drawing, and is forced by its own weight up through the outer milk space to the top of the pas-

teurizer, where it is caught in a trough connecting with the outlet pipe. The milk space is surrounded by a hot-water jacket which heats the milk during its passage. A pasteurizer of this type does not require any machinery to operate it.

A different type of simple milk heater is shown in figure 6. This is known as an internal or double-tube apparatus. It is simply a

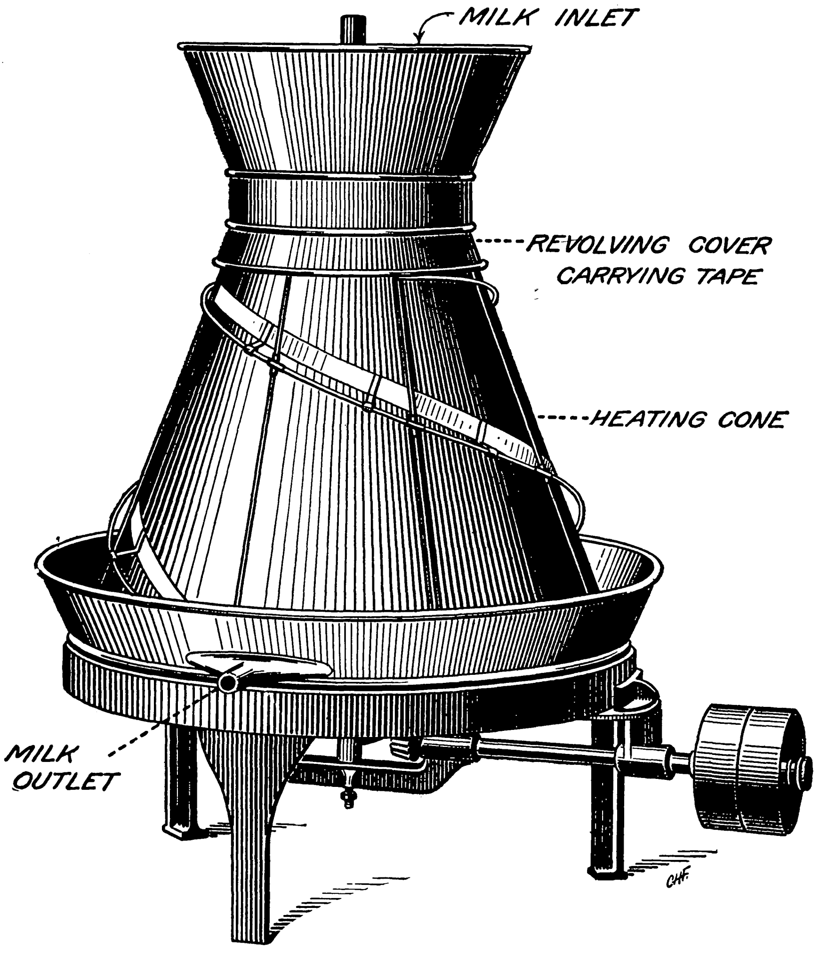

FIG. 4.—Conical type of simple pasteurizer.

series of double-tube pipes, through one of which flows hot water and through the other milk. The water is heated by a steam jet introduced into the water line before it connects with the heating coil. When in operation the milk flows through the inner of the double tubes in the opposite direction to the incoming hot water. The end connection between pipes is constructed so as to be easily removed to facilitate cleaning. The pipes are also built to stand pressure so that

steam under pressure can be used for sterilizing the apparatus. The heater is constructed in sectional units of eight double pipes 8 feet long. By this sectional unit system the capacity of plants may be increased as the requirements demand by the use of additional units.

Several pasteurizers are known as "regenerative" machines. The regenerative principle consists in warming the milk to be pasteurized by allowing it to flow against the hot pasteurized milk, thus cooling the hot milk before it goes to the cooler. In other words, there is a transfer of heat from the hot milk which is to be cooled to the cold milk which is to be heated. A section through one type of regenerative pasteurizer is shown in figure 7. The milk to be pasteurized is discharged into H, from which it runs over the corrugated casing A, where it is heated. The milk is caught in the trough B and pumped through the pipe C into the top of the inner cylinder of the pasteurizer, and from there flows over the steam chamber D, where it is heated to the pasteurizing temperature. The milk passes under the rotating cylinder E and flows up between it and the inner surface of the corrugated cylinder A to the cooler. The hot milk while flowing up between E and A runs in the opposite direction to the cold milk entering the machine. Such an arrangement causes an exchange of heat, cooling the hot milk before it goes to the cooler, and at the same time heating the cold raw milk which is to be pasteurized.

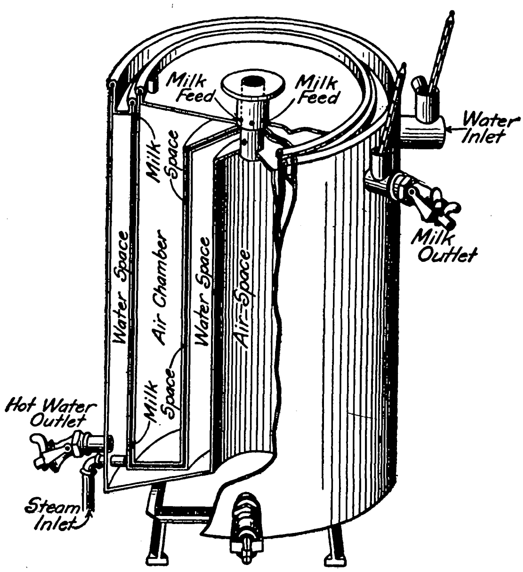

FIG. 5.—A simple pasteurizer through which milk flows by gravity.

Other types of regenerative pasteurizers differ slightly in construction, but the regenerative principle is the same in all cases.

When a holding tank is used the construction of the regenerative pasteurizer has to be slightly changed. The milk is heated and without being cooled is conveyed to the holding tank, from which it flows back to the pasteurizer and from it to the cooler. A section through a machine of this type is shown in figure 8. The course of the milk during the operation of the pasteurizer may be traced from

the drawing. It enters at the top from the feed tank and flows down over two corrugated surfaces, A and B, to the bottom of the machine. There the milk is heated to the desired temperature by being forced by an agitator against the sides of a steam and water jacket. It is then forced to the holding machine, from which, after being held for the proper length of time, the milk flows back to the pasteurizer and is run through the space between the surfaces A and B and then to the cooler. When passing up through these surfaces the hot milk flows against the cold milk which is to be pasteurized, and during its passage the cold milk is heated and the hot milk cooled. The

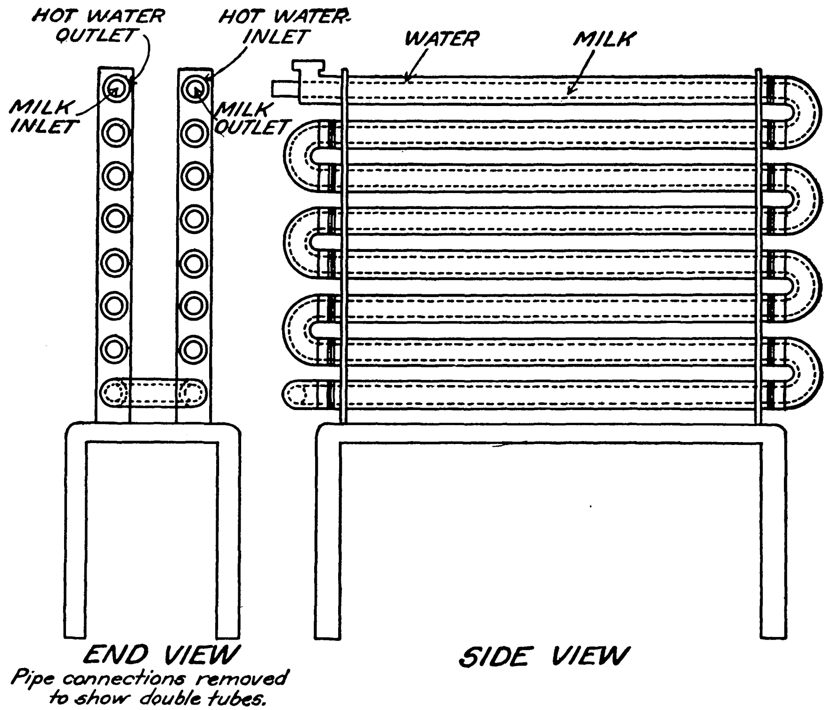

FIG. 6.—A double-tube milk heater. (See also figure 28.)

advantage of the regenerative system is in the use of less steam to heat and less brine to cool the milk.

HOLDING TANKS, RETARDERS, ETC.

Numerous holding tanks and retarders have been designed since the introduction of the holder process of pasteurization. The holding tanks actually hold all the milk the required time, 20 to 30 minutes—that is to say, the flow of milk is stopped and the period of holding dates from that time. Retarders are constructed so that the milk flow is not stopped, but is so retarded that theoretically the

milk is held for the required period. But when retarders are used there is always the possibility of some milk passing directly through without being held the proper length of time. For this reason it seems highly desirable to use apparatus in which there can be no question as to the holding period of all the milk.

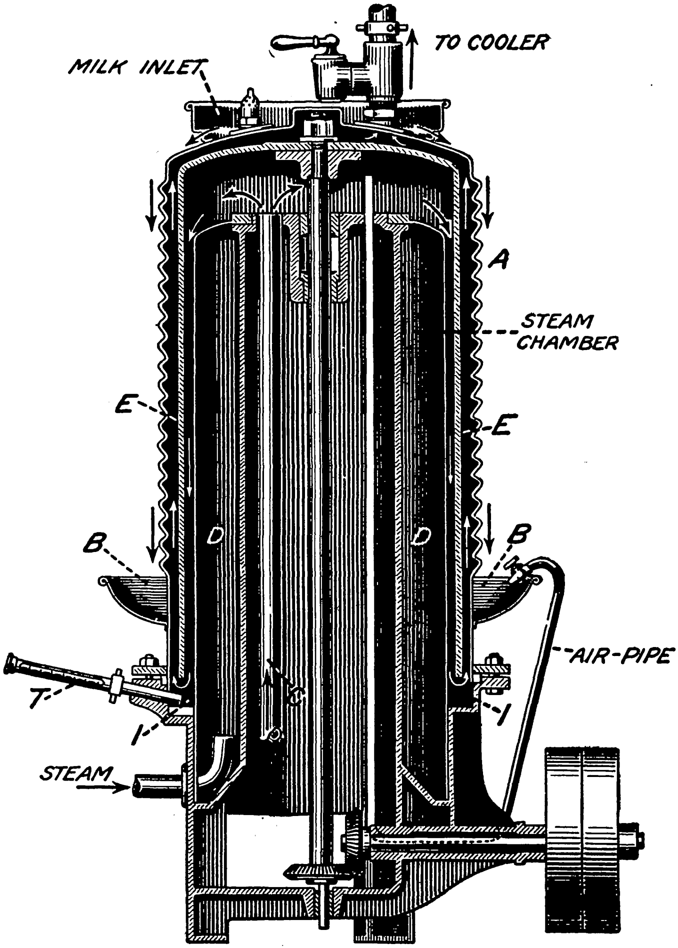

FIG. 7.—A "regenerative" pasteurizer for use without holding tank.

Recently there has appeared upon the market a combination heating, holding, and cooling tank, the arrangement of which is shown diagrammatically in figure 9. This apparatus consists of an insulated tank built in capacities from 1,000 pounds up, in which revolves a spiral agitator carrying hot water for heating and cold water and brine for cooling. The tank is filled with the milk to be pasteurized, and during the filling it is being heated. When the tank is filled,

which takes 30 minutes, the milk is at the desired temperature and the heating is stopped. The milk is heated by circulating hot water, by the aid of a pump, from the water tank around through the revolving spiral heating coil.

Steam to heat the water is blown into the circulating system near the pump. After allowing the milk to stand at the pasteurizing

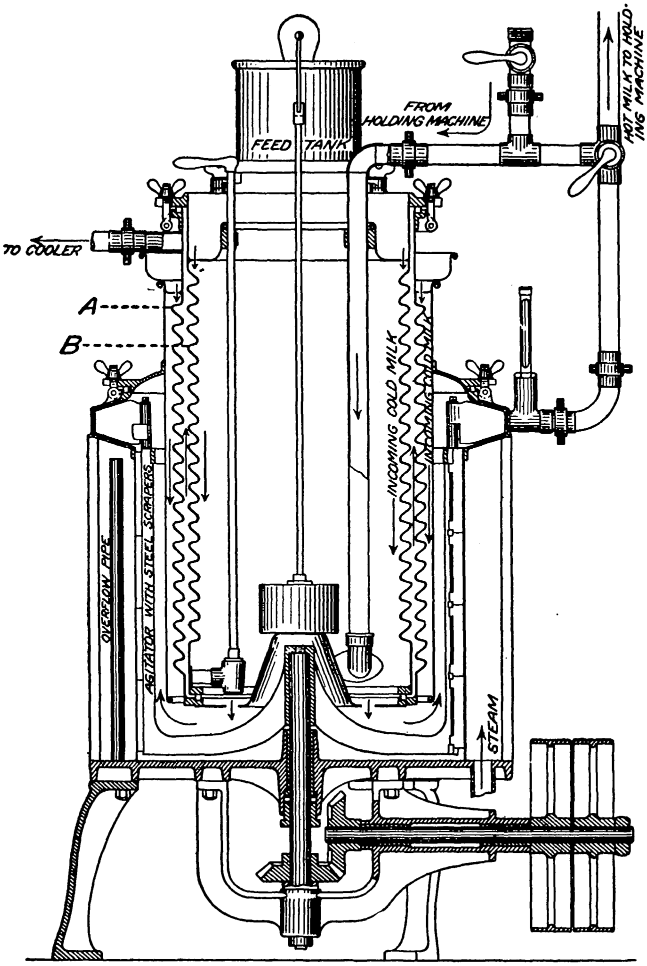

FIG. 8.—A regenerative pasteurizer for use with holding tank.

temperature for 30 minutes the hot water is replaced by cold water and the cooling process is started. When the temperature of the pasteurized milk is reduced as far as possible with the cold water, brine is then circulated through the coil and the cooling is completed. This process requires 30 minutes, making a total of 1½ hours for the complete process. To furnish brine for the cooling ice and salt may be placed in the water tank, or if there is a refrigerating

system in the plant a brine coil may be inserted in the water tank. These tanks are provided with covers which should always be in

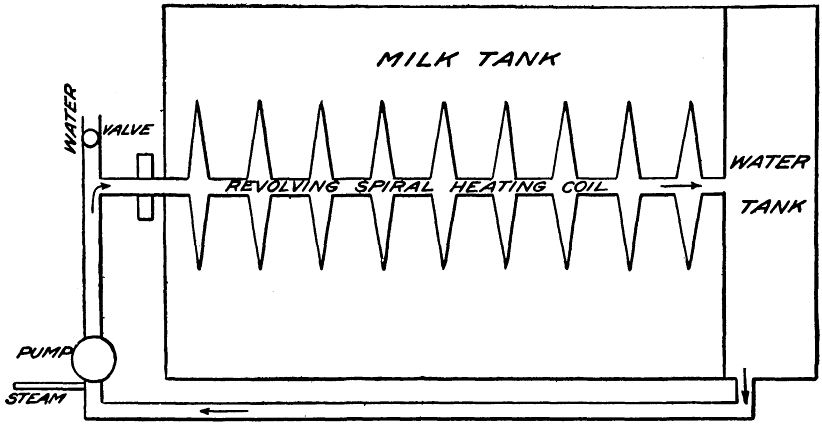

FIG. 9.—Combination heating, holding, and cooling tank.

place during the operation of the machine. A recording thermometer is provided so that the temperature of heating, the length of time of holding, and the cooling temperature may be recorded.

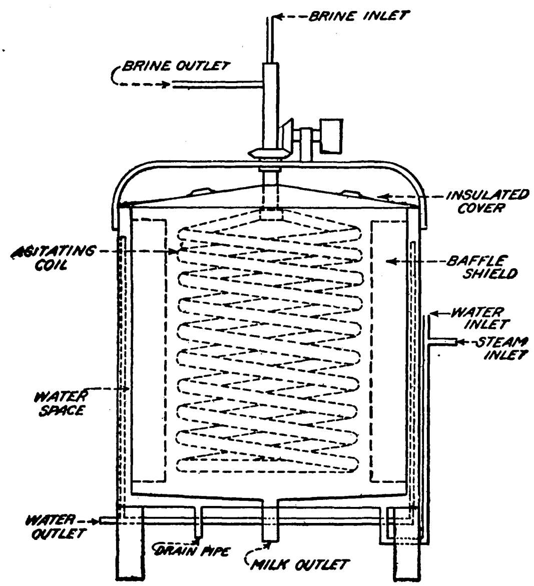

FIG. 10.—Another type of heating, holding, and cooling tank.

In figure 10 another type of apparatus for heating, holding, and cooling is shown. This type of construction eliminates any of the bearings coming in contact with the milk. The machine consists of a tank with steam and water jacket made in capacities from 150 to 500 gallons. Inside of the tank is suspended an agitating coil of the endless type through which brine may be circulated. The hot-water jacket furnishes the heat required, and the milk is circulated by means of the agitator, which, with the assistance of the baffle plates, gives a good circulation. After the milk has been heated and allowed to stand, the cooling process can be started by replacing

the hot water in the jacket with cold water. The process may then be completed by a flow of brine through the agitating coil. This machine also is supplied with insulated covers.

If a plant has a large amount of milk to pasteurize, several of either of these types of tanks may be used to simply heat and hold the milk, the cooling being done by the ordinary types of coolers.

A form of holding tank which simply holds the hot milk is shown in figure 11. This tank is divided into eight compartments, as shown in figure 12. Each compartment has an outlet valve at the bottom operated by an arm connected with the center shaft which passes up through the machine and makes one revolution in 30 minutes. At the top of the shaft is a distributing trough, which fills the eight compartments in 30 minutes. The emptying device is so arranged that six compartments are always filled — one is being filled and one being emptied. By this arrangement one compartment after being filled with hot milk is closed for approximately 30 minutes before it is emptied automatically onto the cooler. The compartments are so arranged as to be completely filled when the machine is going at full capacity; at one-half capacity they would be one-half full. They can therefore be used with small pasteurizing machines.

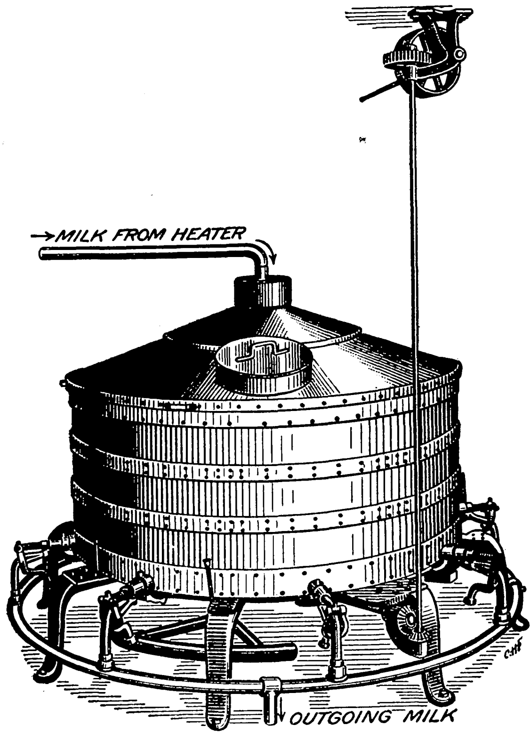

FIG. 11.—Holding tank with automatic emptying device.

The retarders which are in use vary considerably in construction, although the principle is the same. Figure 13 shows a tubular retarder which consists of a series of tubes of sufficient length so that the hot milk from the pasteurizer flowing in at one end takes 30 minutes to reach the other end. The milk flows in at the bottom and out at the top. Connections between the tubes as shown in the figure are of such a nature as to be easily opened to facilitate the cleaning of the apparatus.

A tank retarder is shown in figure 14. This is simply a tank with the milk inlet at the top and the outlet pipe running from the bottom up to nearly the top of the tank. By this arrangement the tank does not begin to empty until the level of the milk in the tank has reached the highest point of the outlet pipe. After reaching that point the flow is continuous. When the flow of incoming milk is stopped the remaining milk in the tank is allowed to run out by opening the valve A.

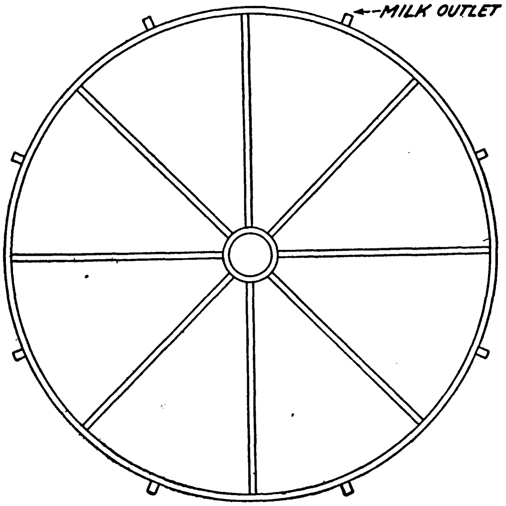

FIG. 12.—Showing compartments and milk outlets of tank in figure 11.

Another type of tank retarder is shown in figure 15, where the construction may be plainly seen. When in operation the hot milk enters through the pipe A and is conducted to the bottom of the first

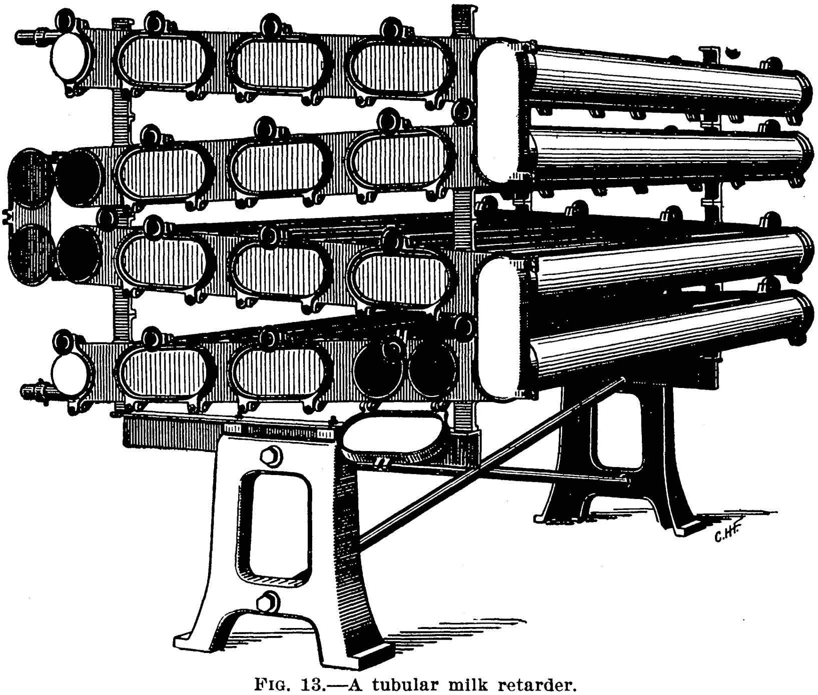

FIG. 13.—A tubular milk retarder.

compartment. As the milk reaches the top of the partition it overflows into the trough C and flows down through the pipe D to the

bottom of the second compartment. This process is repeated until all the compartments are full. When the milk has reached the top of the last compartment it overflows into the funnel B and then is conveyed to the cooler. After the milk has all been pasteurized the tank is emptied by removing the funnel B, which allows the last compartment to empty. When this is empty a plug in the bottom of the next partition is removed, which allows the milk to flow out from the adjoining compartment, and so on until the whole tank is empty. A device of this type retards the flow of milk, so that it requires 30 minutes to pass through the tank.

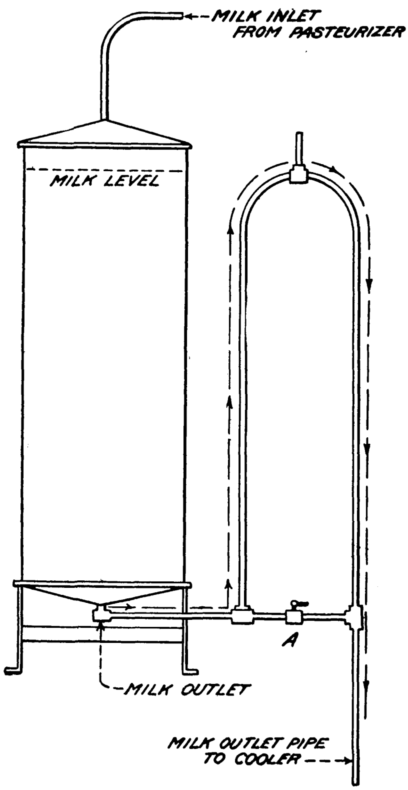

FIG. 14.—A vertical tank retarder.

Figure 16 shows a third type of tank retarder. The tank is divided by a series of partitions open at the alternate ends. Milk enters at the point A and flows around the end of the partition at B, then around the end of the next partition at C, and so on through the tank to the outlet valve. The bottom of the tank on the opposite side from the outlet valve is raised, so as to permit drainage of the tank. When the tank is full of milk the float operates the outlet valve automatically.

The principal objection to holding tanks and retarders is the cost, which in the case of a small plant may be prohibitive. A very simple and cheap holding tank may be constructed from a single wall tank as shown in figure 17. If the capacity of the flash pasteurizer is 1,000 pounds an hour, a holding tank may be made by taking a 100-gallon receiving tank and dividing it by partitions into four compartments of 25 gallons each. An outlet valve should be placed in the bottom of each compartment. With a cover for the tank with milk-inlet pipes to each compartment the apparatus will be complete.

The tank may be set up with sanitary pipe connections from the pasteurizer as shown in figure 18. To operate the tank it is simply necessary to fill compartment A (fig. 17), which, with a 1,000

pounds per hour pasteurizer, will take about 10 minutes. Then fill compartments B and C, which requires the same time for each.

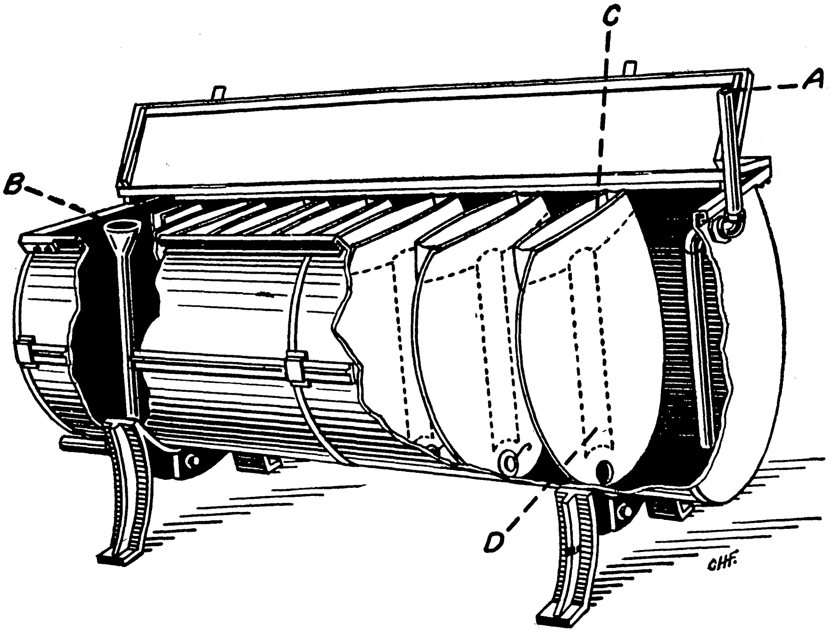

FIG. 15.—Tank retarder with compartments.

When C is full, the outlet valve of A should be opened, and, while it is emptying, compartment D should be filled. The process is then repeated. It will be seen that by such an arrangement the milk is actually held between 20 and 30 minutes, one compartment being held during the filling of the next two.

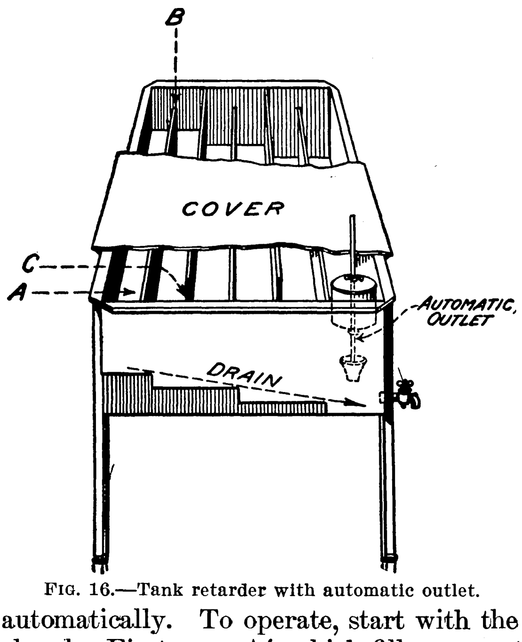

FIG. 16.—Tank retarder with automatic outlet.

In figure 19 is shown a simple arrangement of hand control for filling and emptying the compartments. By the use of connecting bars between the handles of the valves it is only necessary to keep the tanks full of milk, as the outlet valves are operated automatically. To operate, start with the valves A′, B′, C′, and D′ closed. First open A′, which fills compartment A. When full close

A′ and open B′ to fill B, and C′ to fill C. The compartments A, B, and C are then full, and A is ready to be emptied. When valve D′ is opened to fill D, the connecting bar opens valve 1, which empties A. After compartment D is filled, close valve D′, and valve 1 is also closed and compartment A is empty and ready to be filled again. The valve A′ is then opened to fill compartment A, and when opened outlet valve 2 is opened so that B is emptied. In this manner the

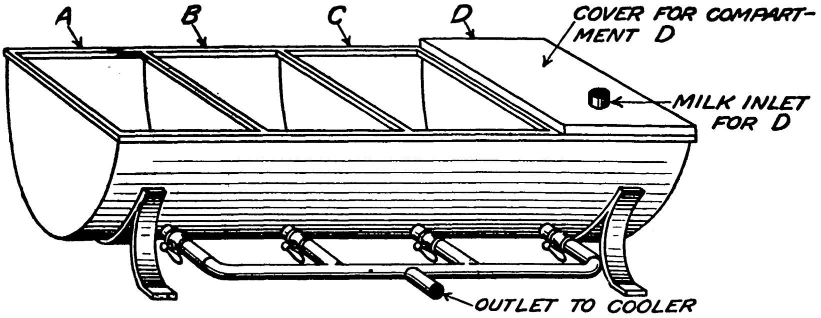

FIG. 17.—A single-wall milk tank converted into a simple holding tank.

process is continued, it being only necessary to operate the filling valves of the tank holder.

Automatic devices may be arranged to operate the filling and emptying, if it is desired, but in a small plant they are hardly necessary. By increasing the capacity of the tanks the output of pasteurizers of any capacity may be held in a similar manner as with the 1,000-pound machine.

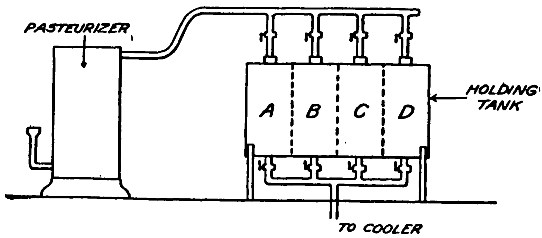

FIG. 18.—Showing method of operating tank in figure 17 with pasteurizer.

MACHINERY FOR PASTEURIZING IN SEALED BOTTLES.

Since pasteurization of milk in sealed bottles has been advocated, some attention has been given to the construction of suitable machinery by the manufacturers of beer-pasteurizing machines. The construction of one type of beer-pasteurizing machine which has been recommended by the manufacturers as adaptable to milk pasteurization is shown in figure 20.

The pasteurizer consists of a round tank (A) and a continuous truck (B) divided into sections of four shelves, on which trays containing bottles are placed. The truck revolves on rollers attached to the bottom of the tank. Two centrifugal pumps (J and K) lift the

water from the bottom of the tank to the water-distribution chamber N, while the spout G fills the trays with water. The water compartment in the bottom of the machine is divided into two sections, one for hot and the other for cold water, which is pumped to the water-distributing chamber N by the pumps J and K. The operation of the machine is as follows: The filled bottles are placed in trays and the latter are placed on the shelves of the revolving truck B. The truck is then started and slowly revolves, carrying the bottles through the warming compartment, then through the pasteurizing chamber, and from there to the cooling compartment, after which they are removed. The water-distributing pans are so arranged that a gradual mixture of hot and cold water is secured in the warming and cooling compartments. The truck makes one revolution in 1 hour and 5 minutes, which allows approximately 27 minutes' actual pasteurization. The pasteurizing compartment is maintained at a constant temperature by a thermostat. This machine is being changed slightly in its construction so as to cool milk to a low temperature.

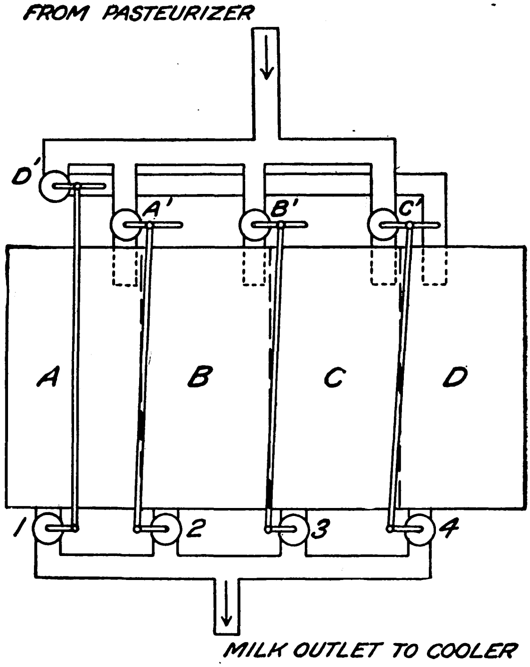

FIG. 19.—Arrangement of hand control for filling and emptying tank in figure 17.

A similar but smaller type of machine is shown in figure 21. The pasteurizer consists of a hollow iron chest (A) with one, two, three, or four sections, according to the capacity, a water pit (B), and doors (C) at both ends. A centrifugal pump (D) is arranged so as to pump water through the pipe F to the distributing chamber G, from which it flows down through the water-distributing pan H. The tracks for trucks are designated by the letter J. K is an overflow pipe to the sewer; L is a thermostat; M, a diaphragm valve; N, steam-pressure gauge; O, air-reducing valve; P, water line and valve; Q, steam line and valve; S, air-pressure gauge; T, thermometer. The operation of the machine is as follows: The filled bottles

are placed on trucks which are rolled into the pasteurizer, the doors are closed, and the steam valve is opened and the pump started. The centrifugal pump draws the water from the pit B and forces it up through the pipe F to the water-distributing chamber G, from which it drops into the distributing pan H, and from there down over the bottles into the pit B. The process is then repeated, making a continuous flow of water, the same water being used over again and repumped about six times per minute. When the pasteurizing process begins, the water in the pit B is of normal temperature, but it is gradually heated by the steam introduced through the steam line Q. As the water gradually heats so do the contents of the bottles. When the temperature in the bottles has reached the pas-

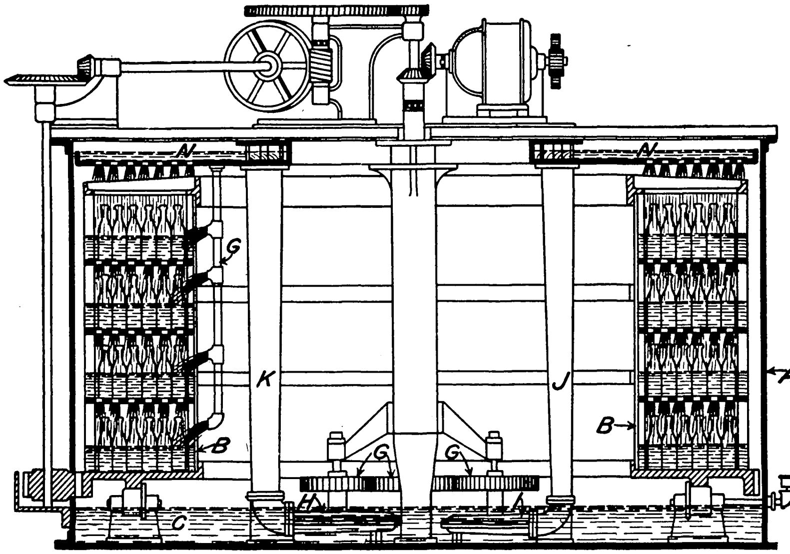

FIG. 20.—A type of beer-pasteurizing machine adaptable to the pasteurization of milk in bottles.

teurizing temperature the thermostat L acts on the air line, which in turn acts on the diaphragm valve N, automatically shutting off the steam; the water in the chamber then remains at a constant temperature, being regulated by the thermostat, which may be set for the desired temperature. When the pasteurizing temperature has been held the proper length of time, an alarm clock gives the signal and the steam is shut off. Fresh cold water is then admitted to the chamber and gradually lowers the temperature of the circulating water until the contents of the bottles have been cooled. The pump is then stopped and the trucks containing the bottles removed. This machine is equipped with brine-cooling coils, so that the contents of the bottles may be brought to a low temperature.

There are numerous types of machines on the market for the pasteurization of beer which may be used for milk, provided suitable attachments are made so as to make it possible to cool the milk to from 40° to 50° F.

Several large milk plants are experimenting at present with this process of pasteurization.

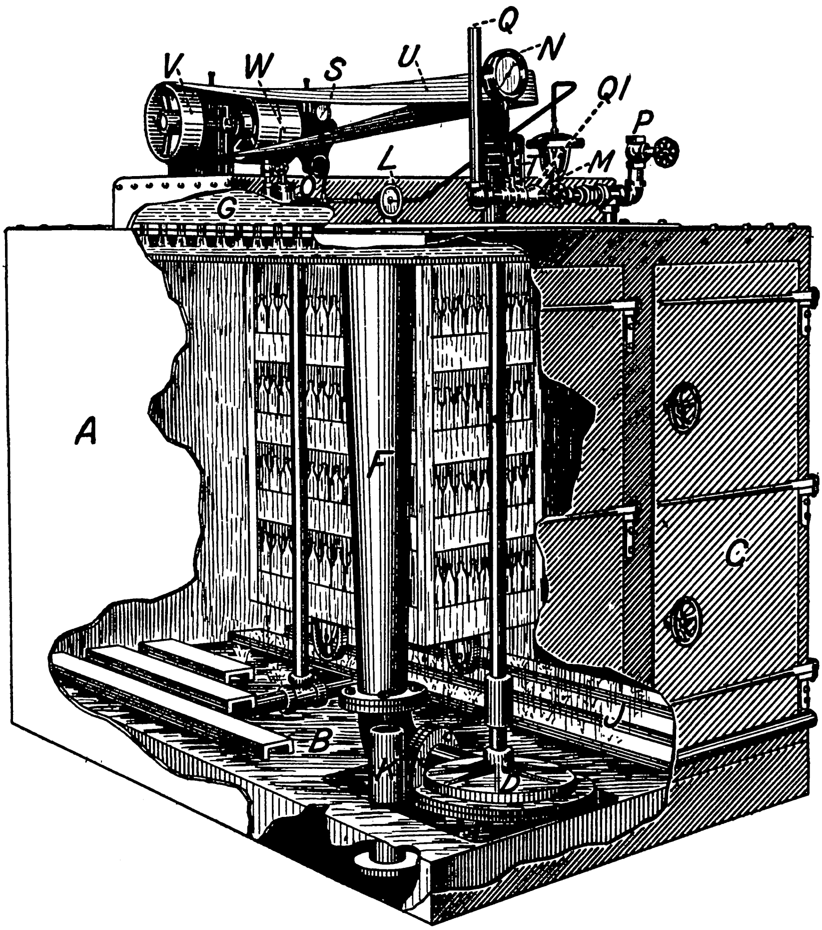

FIG. 21.—Another beer-pasteurizing machine adaptable to milk pasteurization.

COOLERS.

The simple coolers are usually arranged so that the hot milk flows down over the outside of a double corrugated surface, or a series of parallel horizontal pipes standing in a vertical position through which flows cold water and brine. Figure 22 illustrates one of the simple types of coolers. Milk which is to be cooled enters the trough at the top and is distributed by means of rows of holes in the bottom

of the trough, so that it flows in thin sheets over both sides of the corrugated surface into the trough at the bottom. Cold water flows through the upper part of the cooler and brine through the lower part.

There are other types of coolers which comprise the regenerative feature as shown in figure 23. The construction is the same as the simple pipe coolers, except that milk flows through several of the upper pipes. The arrangement is such that the cold milk to be pasteurized is pumped through a number of pipes at the top of the

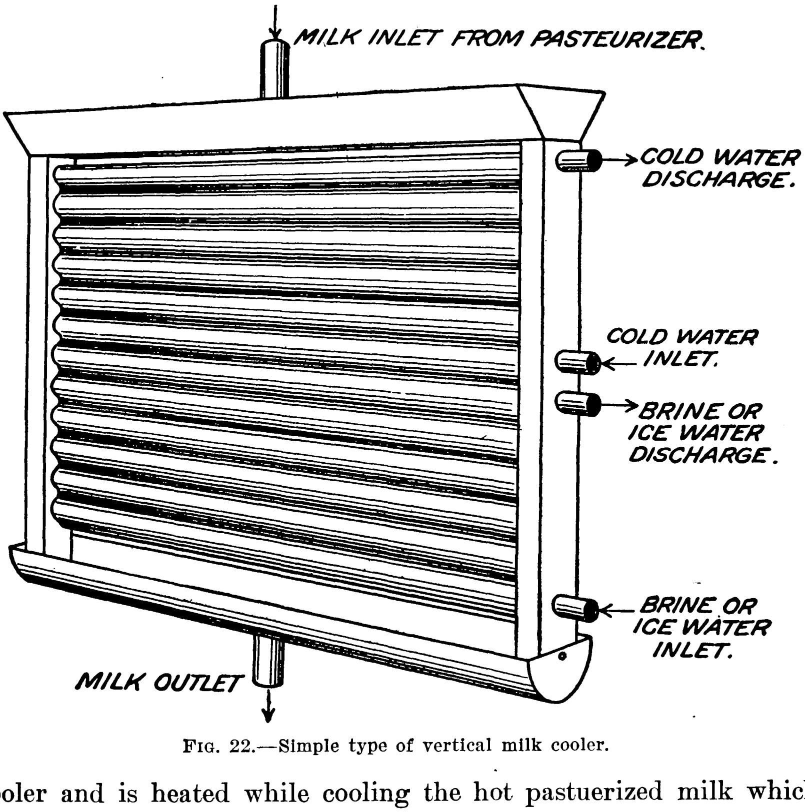

FIG. 22.—Simple type of vertical milk cooler.

cooler and is heated while cooling the hot pastuerized milk which is flowing over the outside of the pipes.

Another type of regenerative cooler is shown in a sectional view in figure 24. In this cooler the cold raw milk flows down over one side of a corrugated surface while the hot milk flows down on the other side. By such construction the cold milk is heated and the hot milk cooled.

Regenerative coolers cause a considerable saving in the cost of heating and cooling. In the selection and operation of a regenerative cooler care must be taken to see that there is no possibility of the infection of the warm pasteurized milk by the raw milk.

In connection with the simple coolers a device known as a regenerator may be used. Figure 25 shows the construction of the apparatus, which consists of four double cylinders with troughs above and below them. The cold raw milk enters the top trough and flows over the outside of the cylinders to the bottom trough, from which it is conveyed to the pasteurizer. After heating, the milk is forced back through the inside of the double cylinders, entering the lower one and leaving through the upper one, from which it flows to a simple cooler. The construction of the double cylinder is such that the milk flows in a thin layer between the wall of the outside cylinder and the surface of the inner cylinder. During the passage

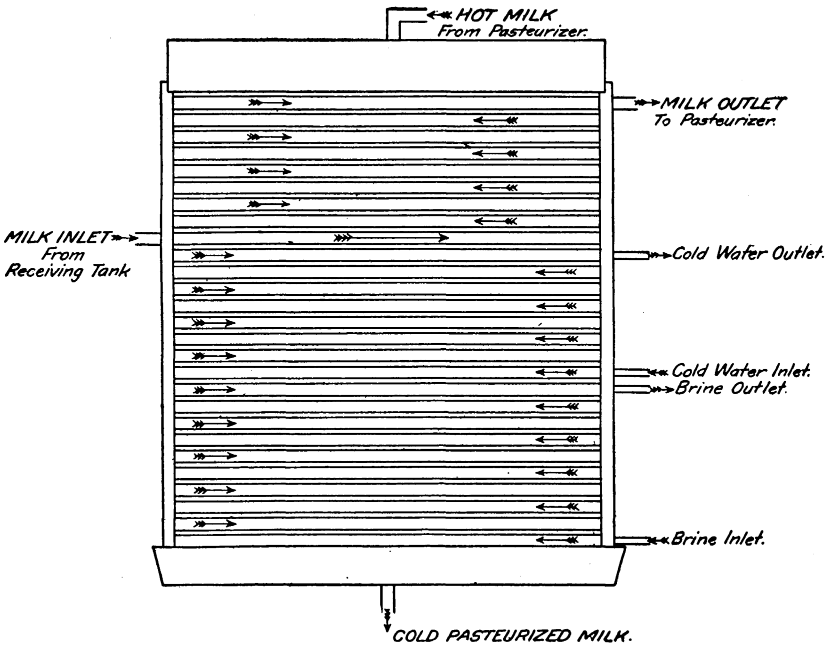

FIG. 23.—Regenerative type of milk cooler.

of the cold and hot milk the cold milk is heated and the hot milk cooled before going to the cooler. A device of this nature saves in the cost of heating and cooling, the same as a regenerative cooler.

Among the other types of coolers is the inclosed cylindrical cooler shown in figure 26. This consists of a cylindrical water jacket inside of which revolves a drum. By the centrifugal action of the revolving drum the milk is drawn over its surface and against the cold water or brine jacket; it is thus cooled and leaves the machine through the discharge pipe. These machines are also constructed so that water or brine may be circulated through the inside revolving drum, thus giving two cooling surfaces.

Figure 27 shows the side and top view of a three-compartment disk cooler which is provided with covers (not shown in the drawing). The milk is cooled by entering compartment C, where it is cooled by a series of revolving disks through which flows cold water. After compartment C is filled the milk overflows to compartment B, where it is cooled in a similar manner as in C. From B it flows to A, where it is cooled by brine flowing through the revolving disks. Sometimes two compartments only are used, one with circulating water and the other with brine. A pasteurizer of this same construction is also in use, compartment C being used for heating.

An entirely different type of cooler is shown in figure 28. This is known as the internal or double-tube cooler. The construction of the cooler is the same as the double-tube milk heater described earlier in this paper and shown in figure 6. The milk heater and coolers are arranged in figure 26 to show the regenerative water circulating system. The two sectional units A constitute the milk heater. The units B, C, D, and E are water coolers, while F and G are brine coolers. When in operation the raw milk enters the milk heater through the milk inlet and after being heated by hot water flows out to a holding tank. From the holding tank it is conveyed to the unit B, where it flows in pipes surrounded by cold water.

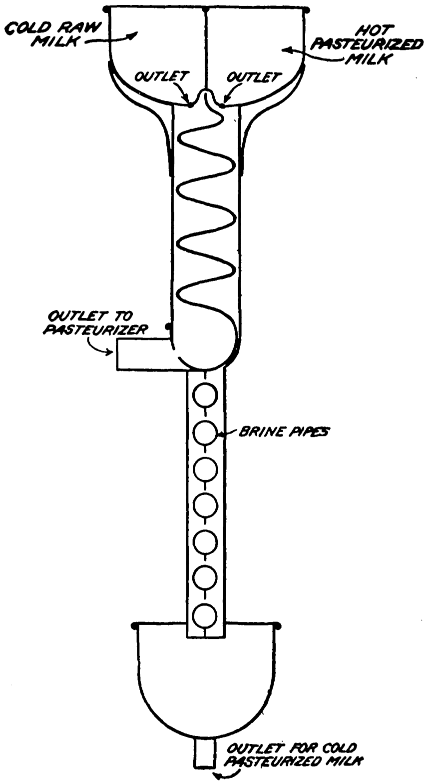

FIG. 24.—Sectional view of another type of regenerative cooler.

The milk is further cooled by cold water in units C, D, and E, and is finally cooled by brine in units F and G, from which it flows to the bottling machine. The brine flows through G and F in an opposite direction to the milk. Cold water enters two units, E and C. That which enters E flows out to the waste pipe through unit D, while that which enters C flows against the hot milk from the holding tank and while cooling it becomes heated. The water after passing through units C and B and having been partially heated is conducted to the heating units A to be used for heating the milk.

Before entering the heating coils the temperature is raised by a steam jet to the point necessary to heat the milk. It may be seen that by warming the water while cooling the milk, less brine is required to cool the milk and less steam to heat the water for pasteurizing.

In the selection of coolers the ease with which they may be cleaned and their efficiency must be considered. It is absolutely necessary that the coolers be inclosed or placed in a separate room which is free from dust. The uncovered simple coolers may be encased in a frame of galvanized iron covered with tin, with doors on both sides to facilitate cleaning, and with a small glass door through which the flow of milk may be observed.

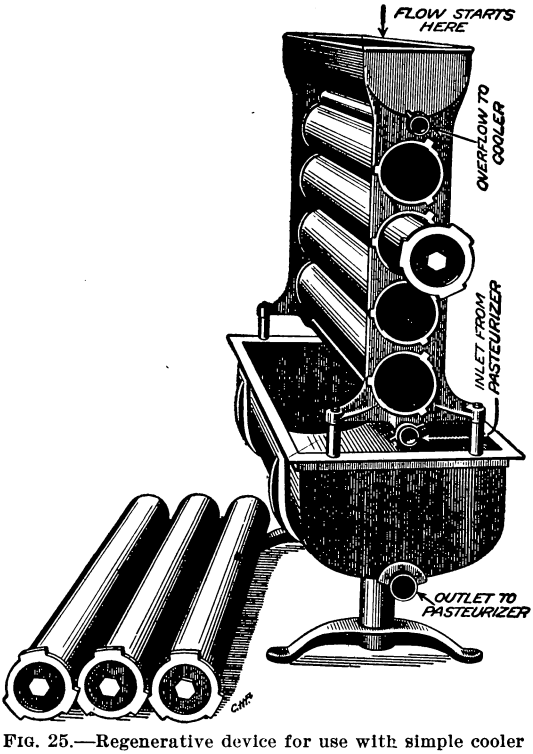

FIG. 25.—Regenerative device for use with simple cooler (three of the drums are removed and the fourth partly removed).

BOTTLING AND CAPPING MACHINES.

Little need be said regarding the bottling and capping machines. The various machines for this purpose are much on the same order and differ only in mechanical details. The essential feature is the accessibility of the parts. Bottles should be capped mechanically and sterilized caps should always be used. When the size of the dairy does not warrant the purchase of an expensive automatic combination bottling and capping machine, a small simple capping machine should be used in connection with a simple bottle filler. Sterilized caps in tubes may be used with such machines. This mechanical process makes it possible to avoid the possibility of infection of the milk by employees in the plant, either from their hands or breath. Under no conditions should the hands of the employee come in contact with the milk after pasteurization, or with the inside of the milk bottles after steaming, or with the sterilized caps. This matter is of the greatest importance in the production of a sanitary product,

PASTEURIZATION ON THE FARM.

Pasteurization on the farm may be highly desirable when the farmer has a local milk route or when farm butter is manufactured. The process is inexpensive, especially when there is a small boiler on the premises, as is usually the case when bottled milk is sold. The machinery necessary for farm pasteurization is a small boiler for generating steam, which may be bought at a cost of approximately $30, and a starter can, which costs about $35 for a can of 30 gallons capacity. The equipment is completed with a bottling and capping machine which varies widely in cost, depending on the capacity and mechanical features. A cooler is not necessary, as the milk may be cooled in the starter can.

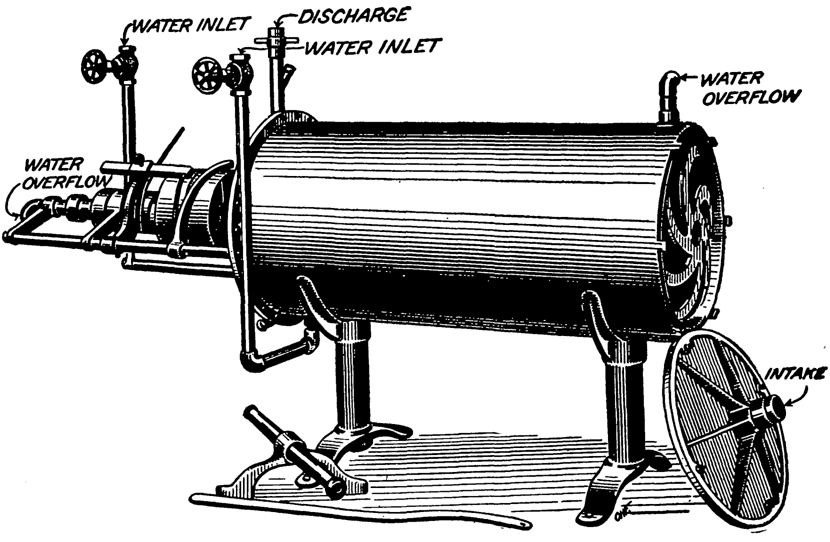

FIG. 26.—A cylindrical inclosed cooler.

The starter can is the essential part of the equipment; it is used to heat the milk, in which capacity it serves as a pasteurizer and holding tank. The starter can is a jacketed can built in various sizes up to 100 gallons capacity and used for the preparation of starters in creameries. The ordinary starter can, after having an outlet pipe placed in the bottom, makes an ideal type of small pasteurizer. Figure 29 shows the construction in detail.

The pasteurizing process may be briefly outlined as follows: The milk, directly after milking, is run into the starter can. Steam is then turned into the jacket of the can or the jacket may be filled with water and then heated by the steam. During the heating of the milk the paddles should be rotated, which may be done by hand or machinery. This circulates the milk and gives a uniform heating.

The milk should be heated to 145° F., as indicated by a thermometer which is inserted into the milk through a hole in the cover of the can. When the desired temperature is reached, which takes about 10 minutes in a 30-gallon can, the steam is turned off and the milk is allowed to stand for from 20 to 30 minutes. After that period of holding it is thoroughly pasteurized and should be cooled at once. A regular cooler may be used, but where the amount of milk is just enough to fill one starter can the cooling may be accomplished in the same can. To do this, the steam connection is unfastened and the hot water in the jacket allowed to run out. This is replaced by cold water, followed by ice water or brine, which is forced through the jacket, entering at the bottom and flowing out at the top. During the cooling the paddle should be rotated to circulate the hot milk against the cold sides of the can. After cooling the milk should be bottled at once in the usual way and must be kept cold until delivered.

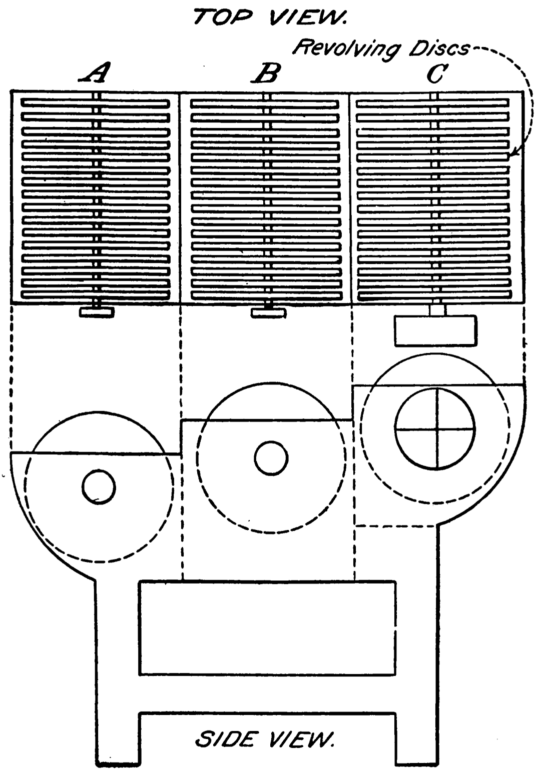

FIG. 27.—A three-compartment disk cooler.

CONSTRUCTION AND ARRANGEMENT OF PASTEURIZING PLANTS.

In a plant of any size the construction of the building and location of apparatus are important. It is impossible to show any one plan of a milk plant which will be suitable for all conditions. In general it may be said that the building should be of brick or concrete. The milk rooms should have concrete floors inclined toward a drain in the center of the room. When the walls are of brick they should be covered with cement plaster, and the junction between the walls and floor should be a smooth curve instead of an angle. This construction is to allow smooth surfaces that may be washed easily and to prevent the accumulation of dirt.

Tiled walls are very satisfactory but expensive.

The milk-receiving room, pasteurizing room, and bottle-filling room should be separate whenever possible.

The selection of machinery varies with the size of the plant. Simple, inexpensive machinery may often be used in a plant pasteurizing 1,000 quarts daily, thus reducing the original cost of the plant and interest on the investment. The small plant may use one of the small, simple pasteurizers, and by running milk into a series of simple tanks, as previously described, have an inexpensive holding system of pasteurization. In the large plants more complicated and

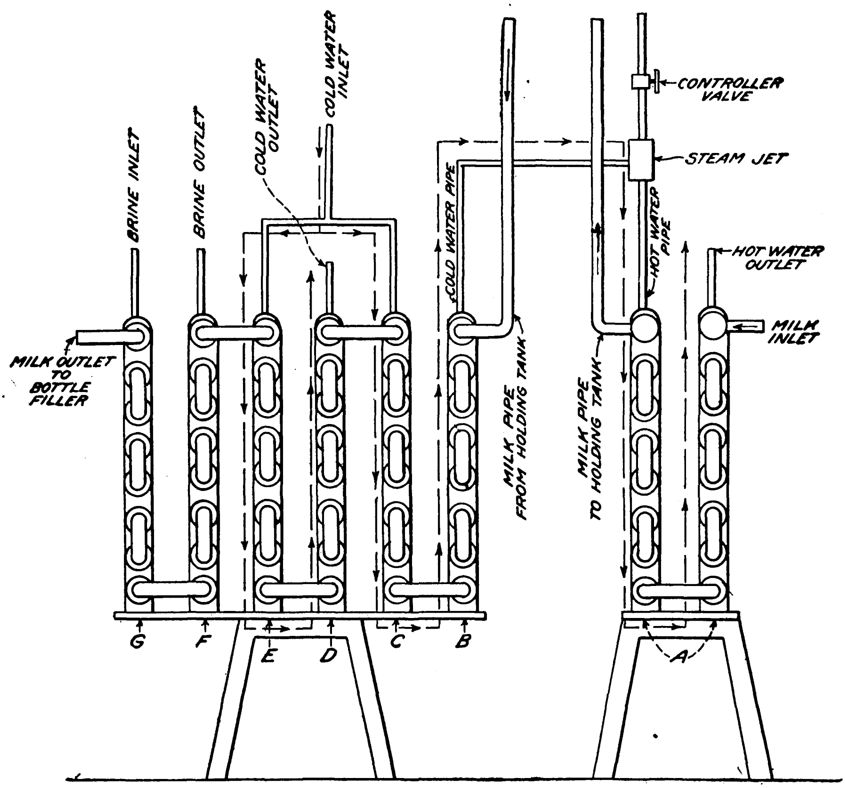

FIG. 28.—A double-tube cooler, as operated with double-tube heater shown in figure 6.

expensive machinery may be necessary on account of the amount of milk to be treated.

The location of the apparatus will depend upon the construction of the buildings. The gravity system of milk flow is the ideal one; therefore the machinery should be located whenever possible so as to avoid the use of pumps. In the gravity system the milk starts from the receiving tank and flows by gravity to the pasteurizer, from there to the holding tank—or cooler, if no holding device is used—and then to cooler and bottling machine. Such a system does away with the use of pumps, which are hard to clean. This arrangement

may be often accomplished by pumping the milk to the receiving tank at the highest level. Any milk pumps which are to be used should be placed in the system before the milk is heated and never afterwards. The piping distances should be as short as possible for reasons discussed later in this paper.

The same care of machinery and other equipment of the plant, together with sanitary conditions and methods, must be observed regardless of the size of the plant. The rooms must be kept absolutely free from flies.

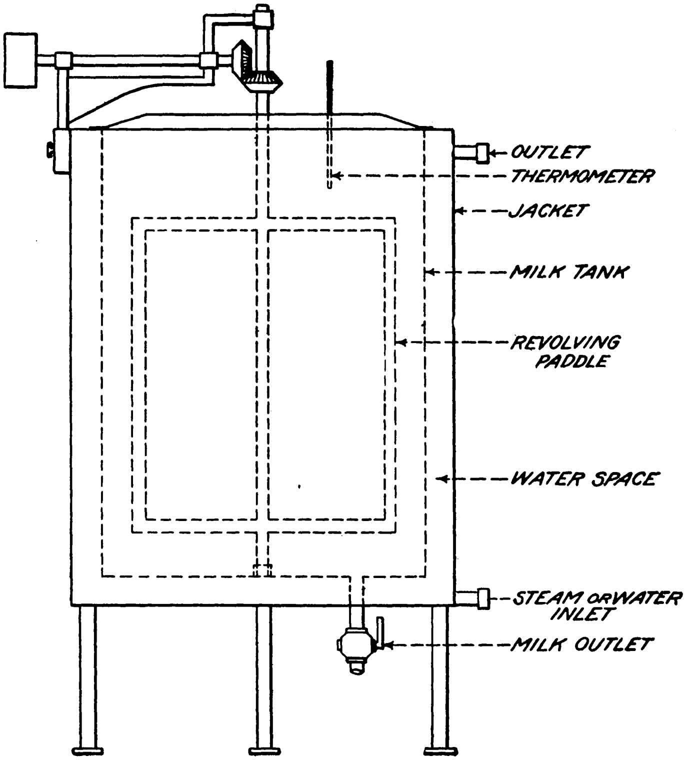

FIG. 29.—A starter can, suitable for pasteurizing on the farm.

CARE OF MACHINERY.

The most modern machinery will not give good results unless cleaned carefully and intelligent care is exercised with it. Occasionally, while the principal features of the process of pasteurization are perfect, it is found that the efficiency of the machine as determined by the percentage bacterial reduction is greatly lowered. When the same grade of milk is being pasteurized with the bacterial counts on the raw milk running evenly, and using the same temperatures for pasteurization, it may be a puzzle to the operators of the machine to determine why the efficiency varies. This may often be

attributed to improper cleaning of the machinery or apparatus in some part of the process. Let us consider a number of points where bacterial infection may take place after the milk is received at the plant:

The receiving tanks may not be clean, due to careless washing, or if thoroughly clean on previous day, dust may have settled in the tank since the washing. Obviously the bacterial content of raw milk will be greatly increased by such conditions. After being emptied of milk the tank should be rinsed out with warm water and scrubbed with some washing compound, then rinsed with hot water and steamed. Just previous to receiving the milk the tank should again be rinsed to remove dust and blown out with steam. The tanks should be covered, and at no step in the process should the milk be freely exposed to the atmosphere of the room.

At the next step in the process the separator must be cleaned in a similar way as the tanks. If cotton filters are used, see that the cotton is placed in even layers and used fresh at each pasteurization. When quartz or sand filters are used the utmost care must be taken to see that the filtering material is thoroughly washed and sterilized by steam, otherwise the bacterial content of the milk may be increased by washing out bacteria already in the filter. When properly operated these filters will remove sediment, but have little or no effect on the bacteria.

The pasteurizer when not thoroughly clean adds to the bacterial content in the same way as the other machinery. Accessibility of parts is an important factor in cleaning. The pasteurizer and holding tank should be rinsed with hot water just before using. Holding tanks should be simple in construction and have no crevices where dirt may lodge. The simple tank with spun edges is easy to clean and does not harbor dirt which may serve to contaminate the milk.

Earlier in this paper reference was made to infection of milk in coolers exposed to the open air. The bacterial content of the milk may be increased when cooling, not only by dust in the air, but also by dust on the cooler and dried milk which was left after washing.

The first milk over the cooler is always higher in bacteria than the following milk on account of having washed off the cooling surfaces. The cooler should in every case be rinsed with water and steamed just before using. The bottling and capping machine is another source of infection unless kept in a thoroughly clean condition. The valves must be given particular attention in cleaning. Pipes in milk plants are often so long and so placed that they can not be taken down to be cleaned, and complicated pumps may cause the dairyman to neglect cleaning when it is necessary. Iron pipes should never be used because the rough surfaces hold filth which is hard to remove. Only sanitary piping should be used, and that should be in

short enough sections to be easily taken down and cleaned. The various parts of pumps should be scrubbed daily with hot water and steamed.

Bacterial examinations of milk in the various steps of the process of pasteurization often reveal dirty machinery. A bacterial count of 2,000 per cubic centimeter in milk leaving the pasteurizing machine and of 40,000 per cubic centimeter in the bottled milk is not to be excused, and is entirely unnecessary, provided minor points of cleanliness are observed.

THE CLEANING OF MILK BOTTLES AND CANS.

Dirty bottles are probably the greatest source of bacterial contamination of milk after it is heated. Bottles often contain millions of bacteria after they have been washed. Washing with warm water is not enough, and even with this the water, which should be boiling or near the boiling point, more often in practice is only lukewarm. In a small plant bottles may be washed by hand, using a revolving brush operated by steam turbine, together with water near the boiling point and washing powder. In large plants a bottle-washing machine will be found useful. After washing, the bottles should be steamed. The most satisfactory way of freeing bottles from possible disease-producing organisms is by thorough washing, then inverting on trucks and steaming in a steam chamber from 20 to 30 minutes. The bottles should then remain inverted in a dustless room, free from flies, until used. If the concrete floor of the milk room is kept wet, most of the dust will be eliminated. In some cases bottles may be sterilized by steam under pressure in an autoclave. While this method is undoubtedly the best from a hygienic standpoint, it is hardly practical on a large scale, due to breakage of bottles and time consumed.

Figure 30 shows a steam chamber for steaming milk bottles. The chambers are built of heavy galvanized iron, with tight-fitting doors. The bottles to be steamed are placed inverted on trucks and run into the chamber; after closing the door, steam is admitted to the chamber through perforated pipes along the bottom. Bottles should be steamed for at least 20 minutes. A longer heating would be desirable; in fact, the longer the heating the more nearly will the bottles be free from bacteria.

Steam chambers may be constructed of brick or concrete, using iron doors. Perforated steam pipes should be placed along the bottom with the holes on top of the pipe so the jets of steam will be directed upward. A pipe should be placed in the top of the chamber to allow steam to escape. This will avoid creating steam pressure in the chamber, which might blow the doors off. Steam chambers of this type have been found to be very satisfactory.

This method of steaming bottles in a steam chamber is ideal, but is often impossible when large numbers of bottles have to be handled on account of the time consumed by the process. It is possible, however, to get practically as good results by steaming the bottles for two or three minutes. This short steaming may be accomplished by

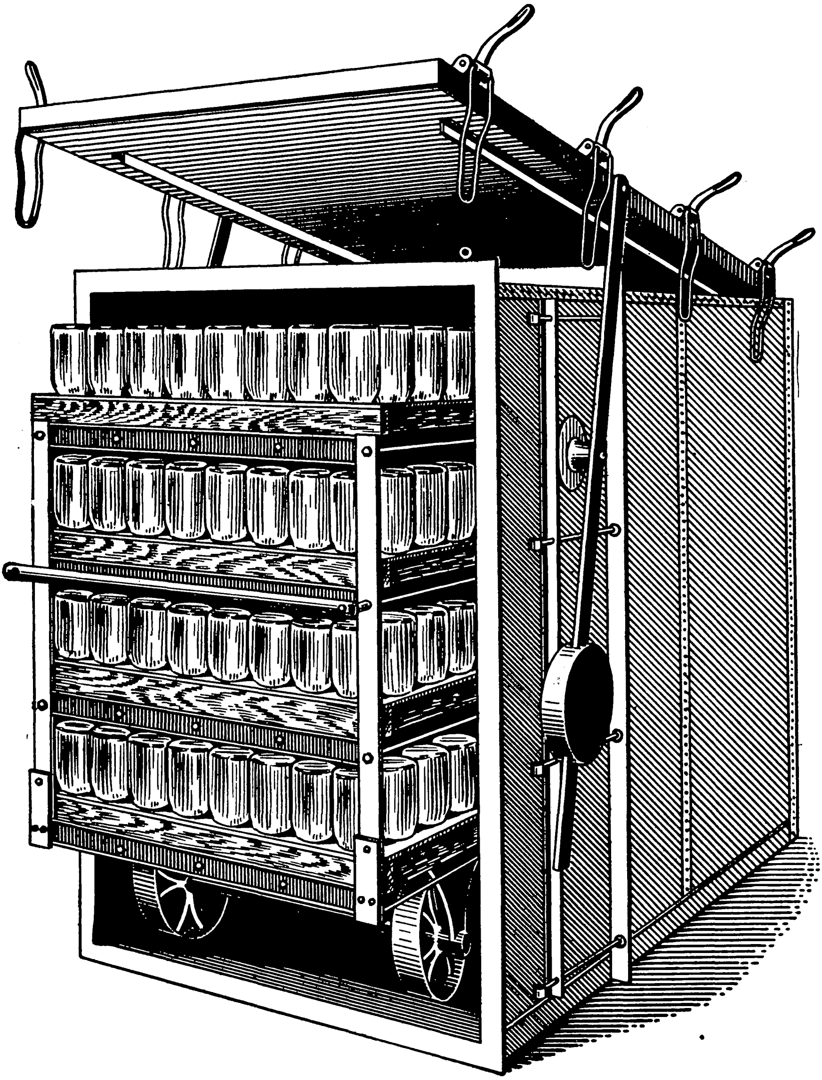

FIG. 30.—Steam chamber, showing method of steaming bottles.

placing the bottles, inverted, in crates on a mechanical conveyer, which carries them through a steam chamber of sufficient size so that the bottles are in the chamber for two or three minutes. The chamber may be made by simply inclosing a part of the conveyer in a galvanized-iron structure, with open ends, so as to allow the crates

of bottles to pass in one end and out the other. Steam should be admitted to the chamber through perforated pipes which run along under the conveyer. The steam will then be blown directly into the inverted bottles while at the same time the chamber is kept full of steam. The bottom of the chamber should be fitted with a waste pipe for condensed steam and so inclined as to carry off the water. When a chamber of this type is used, it should be just wide and high enough to allow a crate of bottles to pass through on the conveyer in order to reduce the amount of steam necessary for the process. The length can be determined only by the speed at which the conveyer is moving, but should be long enough so that, as mentioned before, the bottles will be two or three minutes passing through the steam chamber.

This method of steaming affords a rapid process for steaming a large number of bottles and will give results which are as good, practically, as the longer steaming. It is advisable to steam the bottles just before filling, allowing an interval between steaming and filling just long enough to allow the bottle to cool. This method will reduce the amount of contamination of the bottles, which takes place during the interval of storage between the washing and steaming on one day and the filling with milk on the next day.

Milk cans should be rinsed with cold water as soon as they are emptied, then washed with hot water and some kind of washing powder. After being thoroughly cleaned the cans should be steamed over a can sterilizer for at least two minutes. If possible, cans should be sterilized by steaming in a steam chamber for 20 minutes, the same as milk bottles.

CONTROLLING THE PROCESS OF PASTEURIZATION.

Temperature control is the most important factor in pasteurization. Hand control, when left to a competent man, is satisfactory in a small plant, as the temperature can be regulated within 2 or 3 degrees each way from the desired temperature. In large plants where the process requires some hours, mechanical temperature control is much more certain than hand control. There are numerous temperature controllers, which, with proper care, will run within 1 degree each way of the desired pasteurizing temperature. The temperatures should be recorded in a locked box and should be examined daily by the person in charge of the plant. With a careful watch on the temperature and cleanliness of the apparatus a good product may be assured.

In figure 31 is shown an automatic system of temperature control together with a recording thermometer. The underlying principle of the automatic control is the regulation of the steam flow by a diaphragm valve. The valve is operated by air pressure regulated by

expansion and contraction in the controller bulb, which is inserted in the milk outlet of the pasteurizer. Any temperature desired may be obtained by setting the controller. The bulb of the recording thermometer is inserted in the milk as it leaves the pasteurizer and records the temperature on a chart as is shown in figure 32. This shows the temperature record during pasteurization by the holder process from 7.45 a. m. to about 11.45 a. m. The chart shows that the temperature thus recorded was about 145° F.

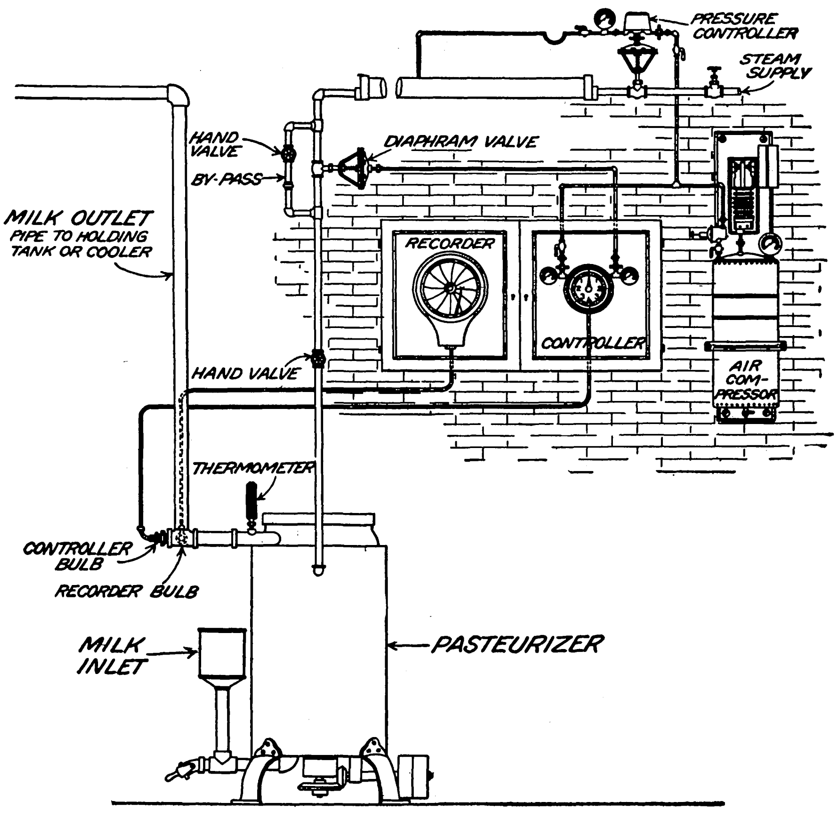

FIG. 31.—An automatic system of temperature control.

When using these automatic devices, care must be taken to see that the controller and recorder bulbs are not exposed to escaping steam or placed against hot surfaces. In other words, they must be affected only by the milk in order to get the correct temperature.

Whenever possible, a bacteriological laboratory should be maintained. The bacterial counts should be made on litmus-lactose-gelatin plates, incubated at 18° C. (64.4° F.) for six days. This medium seems to be the most useful, as it enables one to make a differential count of the bacteria. For the simple determination of the number

of bacteria plain infusion agar may be used. Bacterial examinations should be made daily of the raw milk and of the finished product. At frequent intervals the milk should be examined at various steps in the process to check up the cleaning of the machinery and apparatus. Examinations should also often be made of the bottles, and the number of bacteria in them determined. This is important, since the reinfection of pasteurized milk may be largely attributed to

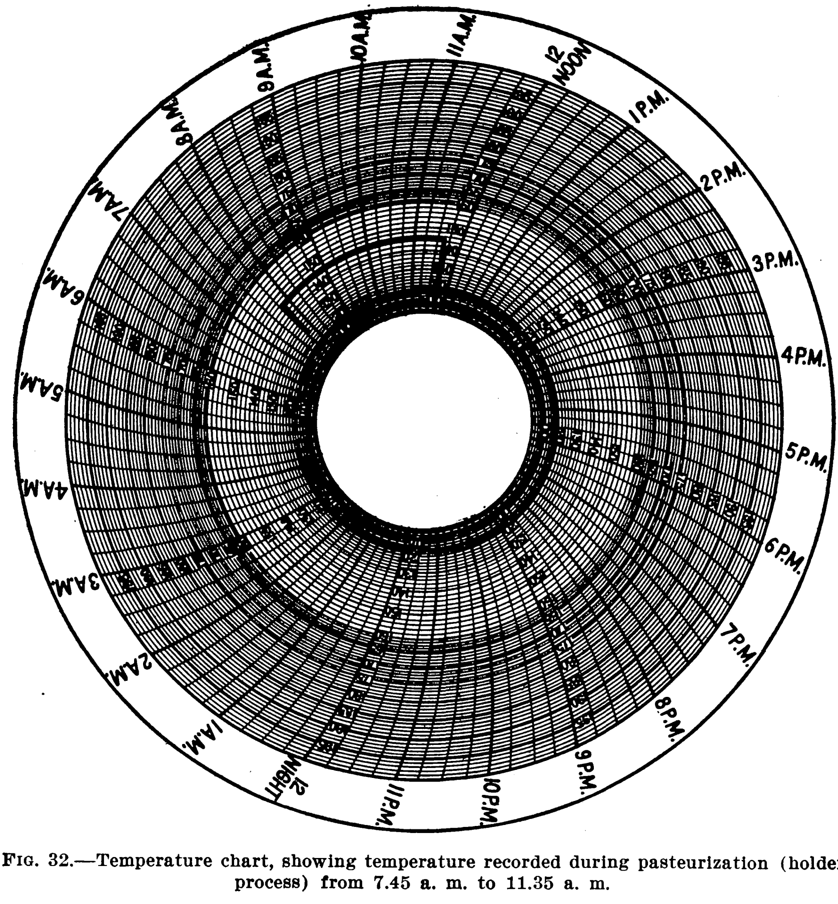

FIG. 32.—Temperature chart, showing temperature recorded during pasteurization (holder process) from 7.45 a. m. to 11.35 a. m.

dirty bottles. The value of bacteriological examinations can not be too highly estimated in the control of pasteurization.

TEMPERATURES AND METHODS TO BE USED.

It is essential to use an accurate thermometer when heating milk. Many of the ordinary thermometers may register a number of degrees away from the correct reading, so the thermometer in use should be tested against a thermometer known to be correct.

As previously stated, the best method of pasteurization at the present time, and the one which should be used, is the holder process, in which the milk is held for 30 minutes. For this process a temperature of 145° F. is to be advised, since that temperature gives a margin beyond that sufficient to destroy pathogenic organisms, while at the same time it leaves in the milk the maximum number of lactic-acid-producing organisms which cause the souring of the milk. When using the flash process, the milk should be heated to at least 160° F. Since there is almost always a fluctuation in the temperature during pasteurization, care should be taken to see that the temperature never drops below 160° F. in the flash process.

The pasteurization of milk in bottles may, in the future, prove to be the best method when suitable machinery is devised for the process.

If the process of bottling pasteurized milk while hot proves satisfactory on a commercial scale, it will undoubtedly be an important improvement on the present system of pasteurizing milk.

HANDLING AND DELIVERY OF PASTEURIZED MILK.

Milk after pasteurization should be cooled as rapidly as possible to 40° F. and kept at that temperature until delivery. During the warm weather it should be iced on the delivery wagons. From a sanitary standpoint all milk, whether raw or pasteurized, should be delivered as soon as possible in order to get it to the consumer in the best condition. In the best pasteurized milk there is only a slight bacterial increase when held on ice during the first 24 hours, yet in many cases the pasteurization and delivery may be so arranged that the consumer may get the milk before any change in the bacterial content has taken place. The cream line is, of course, regarded as an essential feature in market milk since at the present time the public demands it. It is not necessary, however, to hold milk pasteurized one morning until the next in order to get the cream line, for two or three hours' refrigeration is sufficient to get the full amount of cream. The tops of the bottles should be protected from dust, dirt, or other contamination by an overlapping cap, by a paper cover held in place by a rubber band, or by some of the patent secondary caps now on the market. The milk should be marked "pasteurized," with the date and temperature of the process. This information should be printed on the caps for the benefit of the consumer, as it is only right that he should know whether he is using raw or pasteurized milk, and if pasteurized the temperature may be of importance to him. Some people object to using pasteurized milk, especially for infant feeding, while others desire it. It has been the experience of numerous milk dealers that the labeling of their product has greatly increased their trade.

As any grade of milk deteriorates quickly even when placed in the refrigerator consumers should be advised to use milk within 24 hours after delivery and to keep it cold during that time. They should also be advised to provide small insulated boxes in which the delivery man can place the cold milk bottles in warm weather. Very often in the summer months milk is delivered at 2 or 3 o'clock in the morning and is exposed to the sun from sunrise until 6 or 7 o'clock, or later. During that time the temperature of the milk rises and the bacteria increase rapidly. The use of tight insulated boxes will help to keep the milk cold, provided it is iced on the wagons.

The progressive milk dealer would do well to advertise the fact that his milk is produced in a sanitary milk plant and by the most sanitary methods. He should fix a high standard and maintain it for his own benefit as well as his customers.

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